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Abstract

This article considers the case where a number of countries produce goods from labor, government input and natural resources. Because conservation of natural resources anywhere yields utility in all countries and there is no benevolent international government, the coordination of conservation must be delegated to a regulator that may have its own interests. This article examines what is the efficient package of tools for that regulator. It is shown that if the minimum standards for conservation are used, then conservation subsidies are welfare decreasing, involving excessive conservation. This suggests that e.g. in the EU project called NATURA 2000, it is not appropriate to provide ’’co-financing’’ for sites.

JEL Classification: H23, F15, Q24

Keywords: ecological habitats, regulation, conservation subsidies, lobbying, biodiversity

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1 Introduction

This article considers the case where conservation in any country is a world-wide externality (e.g. through biodiversity). Because there is no benevolent international government, conservation management must be delegated to a potentially self-interested regulator. A key question then is how many policy tools are required or efficient in that management and what to do if there are alternative tools. Tinbergen (1952) tells that there must be at least one policy tool for each and every policy target. He also notes that additional ("supplementary" or "complimentary") tools are often required to control side-effects or otherwise bolster a "primary" tool. Are regulatory standards sufficient, or should subsidies as well be used in conservation?

This article is motivated by the following experience. The *European Commission (EC)* manages biodiversity by the *Habitats Directive 92/43/EEC* on the conservation of natural habitats and of wild fauna and flora. That directive established the Natura 2000 network of protected sites. It provides for the inclusion of protected areas under the Birds Directive (Art. 3, Directive 92/43/EEC) and Community co-financing for sites which are of importance for the Community (Art. 8, Directive 92/43/EEC). What is the role of regulatory standards and co-financing in biodiversity management in that case?

MacArthur and Wilson (1967) show that the total variety of species in a habitat is an increasing function of the area of that habitat. Swanson (1994), Barbier and Schulz (1997) and Endres and Radke (1999) consider the optimal area of a habitat when the variety of species yields utility, comparing the benefits of maintaining the habitat with those of using land in production. Barrett (1994), Swanson (1996), Sarr et al. (2008), Gatti et al. (2011) examine biodiversity management in an economy where some countries (called the "South") are highly endowed with biodiversity, while the others (called the "North") are the primary location of the research and development industries relying upon these resources. In this article, I assume that all countries are endowed with resources that can contribute an international public good (e.g. biodiversity). Winands et al. (2013) examine the possibility for cooperative biodiversity agreements when the economy consists of heterogeneous countries. In constrast, I consider the political economy solution where countries lobby the self-interested regulator that performs conservation management.

Lobbying can be modeled either by the *all-pay auction model*, in which the lobbyist making the greater effort wins with certainty, or by the *menu-auction model*, in which the lobbyists announce their bids contingent on the politician's actions. In the all-pay auction model, lobbying expenditures are incurred by all the lobbyists before the regulator takes an action.[1] In the menu-auction model, it is not possible for a lobbyist to spend money and effort on lobbying without getting what he has lobbied for. Because this article examines the case where the regulator's decision variables (e.g. regulatory constraints, subsidies) are continuous and the interest groups (e.g. countries) obtain marginal improvements in their position by lobbying, the menu-auction model is a proper basis for the study.

Palokangas (2013) examines biodiversity management in the case where identical countries produce the same good and perform R&D. He shows that if the subsidies are financed by a distorting consumption tax, then the introduction of subsidies harms welfare. In contrast in this document, I examine a more relevant case where the countries are heterogeneous, but simplify the analysis by replacing R&D by government input to production as an alternative source of employment. To focus on the heterogeneity of the countries, I assume that taxation is non-distorting.

This article is organized as follows. Section 2 specifies the structure of the model. Section 3 considers the behavior of the firms, countries and households. Section 4 constructs the Pareto optimum as a point of reference. Section 5 present the self-interested regulator. The political economy of regulation without subsdies is examined in section 6 and that with subsidies in section 7. The results are summarized in section 8.

2 The economy

In the economy, there is a large number ("continuum") of countries within the limit $[0, 1]$. Because conservation in any country yields common externality, there is a self-interested regulator that manages conservation. To obtain an equilibrium with lobbying, I assume that if country $i \in [0, 1]$ doesn't not involve in conservation management, then it pays a penalty $\xi_j > 0$ to the

[1]For instance, in Johal and Ulph (2002), local interest groups lobby to increase the probability of getting their favorite type of government elected.

other countries. All countries $i \in [0,1]$ supply the same good, which is chosen as the numeraire in the model, derive utility from consumption and conservation, and lobby the regulator by their political contributions. In this setup, I examine what is the efficient package of tools for the regulator.

Country i allocates its given labor L_i between production l_i and public services z_i and its given natural resources N_i between production n_i and conservation b_i:[2]

$$L_i = l_i + z_i, \quad N_i = n_i + b_i. \tag{1}$$

There are two stages of production. First, the local government of each country $i \in [0,1]$ produces public services z_i from labor according to constant returns to scale and finances this by local taxes. Second, local firms produce their output y_i from labor l_i, natural resources n_i and public services z_i according to the thrice differentiable and strictly concave function

$$y_i = f^i(l_i, n_i, z_i), \quad f^i_l > 0, \quad f^i_n > 0, \quad f^i_z > 0, \quad f^i_{ll} < 0, \quad f^i_{nn} < 0, \tag{2}$$

where the subscripts l, n or z denote partial derivatives of f^i with respect to l, n or z, correspondingly.[3]

The political economy of environmental policy is expressed as an extensive form game with the following stages: (I) The lobbies influence the regulator, relating their prospective political contributions to the latter's decisions. (II) The regulator decides its policy and collects political contributions. (III) The countries conserve habitats and produce public services. (IV) The firms produce the good. This game is solved in reverse order: stages (IV) and (III) in section 3 and stages (II) and (I) in 6 and 7.

[2]I assume that the quantity of natural resources in country i, N_i, is a scalar. With some complication, the model can be generalized for the case where N_i is a vector of many habitats in country $i \in [0,1]$, but this does not qualitatively contribute to the analysis.

[3]It is is necessary to introduce some other source of employment than private production to observe the difference of regulatory standards and subsidies in conservation management. Palokangas (2013) uses R&D for that purpose, but this complicates his model so much that he can consider only the case of identical countries. In this document, I use the demand for labor in government services for the same purpose.

3 Firms, countries and households

The regulator has the following country-specific tools. First, it determines the minimum amount m_i of natural resources (called hereafter the *regulatory standard*) that must be devoted to conservation:

$$b_i \geq m_i \text{ with } m_i \in [0, N_i] \text{ for } i \in [0, 1]. \tag{3}$$

Second, it can provide "co-financing" for protected sites (cf. Art. 8, Directive 92/43/EEC). This is modeled as an *ad valorem* subsidy s_i to natural resources being used for conservation over and above the regulatory standard, $b_i - m_i$.[4] To finance these subsidies, the regulator is allowed to collect a uniform tax t from all countries. To keep that tax non-distorting, let it be the poll tax,

$$t_k = tL_k \text{ for } k \in [0, 1], \tag{4}$$

where L_k is the given labor supply in country k.

Firms use natural resources n_i up to the level at which the rent r_i for these is equal to the marginal product of these, $r_i = f_n^i(l_i, n_i, z_i)$ [cf. (2)]. The *subsidy base* in country i, V^i, is then equal to the rent r_i times conserved resources over the regulatory standard, $b_i - m_i$, in that country. Noting (1) and (2), that base can be defined as follows:

$$\begin{aligned} V^i(z_i, b_i, m_i) &\doteq r_i(b_i - m_i) = (b_i - m_i)f_n^i(l_i, n_i, z_i) \\ &= (b_i - m_i)f_n^i(L_i - z_i, N_i - b_i, z_i), \quad V_m^i \doteq \frac{\partial V^i}{\partial m_i} = -f_n^i < 0, \\ V_z^i \doteq \frac{\partial V^i}{\partial z_i} &= (b_i - m_i)(f_{nz}^i - f_{ln}^i), \; V_b^i \doteq \frac{\partial V^i}{\partial b_i} = f_n^i - (b_i - m_i)f_{nn}^i > 0. \end{aligned} \tag{5}$$

Because each country $i \in [0, 1]$ pays political contributions R_i to the regulator, the latter receives total contributions

$$R \doteq \int_0^1 R_i di. \tag{6}$$

Noting (1), (2) and (5), one obtains the revenue in country i:

$$\begin{aligned} \pi_i(z_i, b_i, m_i, s_i, t_i + R_i) &\doteq y_i + s_i r_i(b_i - m_i) - t_i - R_i \\ &= f^i(L_i - z_i, N_i - b_i, z_i) + s_i V^i(z_i, b_i, m_i) - t_i - R_i, \quad \frac{\partial \pi_i}{\partial m_i} = s_i V_m^i, \end{aligned} \tag{7}$$

[4] I assume that a direct subsidy to the quantity b_i of a habitat is incentive incompatible. Therefore, the regulator rather bases the subsidy s_i on the value (5) of that habitat.

where y_i is output, s_i the subsidy for the value $r_i(b_i - m_i)$ of conserved resources b_i over and above the standard m_i, t_i a tax and R_i contributions that are paid to the regulator. Country i determines public services z_i and controls conserved resources b_i by local taxes that do not appear in the net revenue (7) of the country.

If country i involves in conservation management, then it maximizes its revenue (7) by public services z_i and conserved resources b_i subject to the regulatory constraint (3). This leads to the following equilibrium conditions (cf. Appendix A)

$$\Pi_i(m_i, s_i, t_i + R_i) \doteq \max_{z_i,\, b_i \geq m_i} \pi_i(z_i, b_i, m_i, s_i, t_i + R_i), \tag{8}$$

$$\frac{\partial \Pi_i}{\partial(t_i + R_i)} = \frac{\partial \pi_i}{\partial(t_i + R_i)} = -1, \quad \frac{\partial \Pi_i}{\partial s_i} = \frac{\partial \pi_i}{\partial s_i} = V^i, \tag{9}$$

$$s_i V_z^i(z_i, b_i, m_i) - f_l^i(L_i - z_i, N_i - b_i, z_i) + f_z^i(L_i - z_i, N_i - b_i, z_i) = 0, \tag{10}$$

$$s_i V_b^i(z_i, b_i, m_i) - f_n^i(L_i - z_i, N_i - b_i, z_i) \begin{cases} = 0 & \text{for } b_i > m_i, \\ < 0 & \text{for } b_i = m_i, \end{cases} \tag{11}$$

$$\frac{\partial \Pi_i}{\partial m_i} = s_i \big[V_m^i(z_i, b_i, m_i) + V_b^i(z_i, b_i, m_i)\big] - f_n^i(L_i - z_i, N_i - b_i, z_i). \tag{12}$$

Given (2) and (11), the regulatory constraint (3) is binding without a subsidy:

$$-f_n^i < 0, \quad b_i\Big|_{s_i=0} = m_i, \quad \frac{\partial b_i}{\partial m_i}\bigg|_{s_i=0} = 1. \tag{13}$$

Because the production function (2) is thrice differentiable, the subsidy base (5) is twice differentiable and the first-order conditions (10) and (11) define diffentiable response functions for country i (cf. Appendix A):

$$z_i(m_i, s_i), \quad b_i(m_i, s_i), \quad \frac{\partial b_i}{\partial s_i}\bigg|_{s_i=0} > 0. \tag{14}$$

In other words, a small subsidy s_i to conservation increases resources b_i devoted to conservation.

If country i does not involve in conservation management, then it pays the penalty ξ_i, but does not obtain the subsidy, $s_i = 0$, and avoids paying taxes, regulatory standards and political contributions, $t_i = m_i = R_i = 0$. In that case, its revenue is the constant [cf. (7)]

$$\underline{\pi}_i = \max_{z_i,\, b_i \geq 0} f^i(L_i - z_i, N_i - b_i, z_i) - \xi_i = \max_{z_i} f^i(L_i - z_i, N_i, z_i) - \xi_i. \tag{15}$$

Total consumption c is the sum of the outputs y_i of all countries $i \in [0,1]$ [cf. (1) and (2)]:

$$c \doteq \int_0^1 y_i di = \int_0^1 f^i(l_i, n_i, z_i) di = \int_0^1 f^i(L_i - z_i, N_i - b_i, z_i) di. \qquad (16)$$

To avoid distributional considerations, I examine the representative household of the whole economy. This derives utility u from consumption c and the conserved natural resources of all countries, $\{b_i\} \doteq \{b_i |\, i \in [0,1]\}$, according to the function

$$u(c, \{b_i\}), \quad \frac{\partial u}{\partial c} > 0, \ \frac{\partial u}{\partial b_i} > 0 \ \text{ for } i \in [0,1], \ \ u \text{ strictly concave.} \qquad (17)$$

4 Pareto optimum

Given the response functions (14) of the regions $i \in [0,1]$, a benevolent regulator can control both conserved resources b_i and public services z_i by the regulatory standard m_i and the subsidy s_i throughout all countries $i \in [0,1]$. It maximizes the welfare of the representative household, (17), by the instruments $\{b_i\} \doteq \{b_i |\, i \in [0,1]\}$ and $\{z_i\} \doteq \{b_i |\, i \in [0,1]\}$ subject to total consumption (16). This leads to the first-order conditions [cf. (2) and (16)]

$$\frac{\partial u}{\partial c}\frac{\partial c}{\partial z_i} = (f_z^i - f_l^i)\frac{\partial u}{\partial c} = 0 \ \text{ and } \ \frac{\partial u}{\partial b_i} + \frac{\partial u}{\partial c}\frac{\partial c}{\partial b_i} = \frac{\partial u}{\partial b_i} - f_n^i \frac{\partial u}{\partial c} = 0 \ \text{ for } i \in [0,1].$$

These in turn can be written as the *Pareto optimality conditions*:

$$f_z^i = f_l^i \ \text{ for } i \in [0,1], \qquad (18)$$

$$\frac{\partial u}{\partial b_i}\bigg/\frac{\partial u}{\partial c} = f_n^i \ \text{ for } i \in [0,1]. \qquad (19)$$

Efficiency of production, (18), says that the marginal product must be the same for both private labor l_i and government labor z_i in every country $i \in [0,1]$. *Efficiency of conservation*, (19), says that, in each country $i \in [0,1]$, the marginal rate of substitution between consumption and natural resources must be the same in utility and production.

Plugging the condition (18) into the equilibrium conditions (10) of the countries $i \in [0,1]$ yields that the subsidies s_i corresponding to the Pareto optimum are zero for all countries $i \in [0,1]$. In other words:

Proposition 1 *The benevolent regulator does not introduce subsidies, $s_i = 0$ for $i \in [0,1]$.*

5 The self-interested regulator

Given taxation (4), the definition of the opportunity cost, (5), and the response functions (14) of the countries $i \in [0,1]$, the regulator's budget is

$$t \int_0^1 L_k dk = \int_0^1 s_i r_i b_i di = \int_0^1 s_i V^i \big(z_i(m_i, s_i), b_i(m_i, s_i)\big) di, \tag{20}$$

where $t \int_0^1 L_k dk$ is total tax revenue and $\int_0^1 s_i r_i b_i di$ total subsidies. The budget constraint (20) defines the tax t as a function of the policy variables $\{m_k\} \doteq \{m_k | \, k \in [0,1]\}$ and $\{s_k\} \doteq \{s_k | \, k \in [0,1]\}$ as follows:

$$t\big(\{m_k\}, \{s_k\}\big), \quad \frac{\partial t}{\partial m_i}\bigg|_{s_k=0\,\forall k\in[0,1]} = 0, \quad \frac{\partial t}{\partial s_i}\bigg|_{s_k=0\,\forall k\in[0,1]} = \frac{V^i}{\int_0^1 L_\kappa d\kappa}. \tag{21}$$

To avoid distributional considerations that result from the payment of contributions R_i, $i \in [0,1]$, I assume that all countries $i \in [0,1]$ and the regulator belong to the representative household.[5] Consumption c is then equal to the revenues π_k from countries $k \in [0,1]$ plus the regulator's revenue R [cf. (4) and (8)]:

$$c = \int_0^1 \pi_k dk + R = \int_0^1 \Pi_k(m_k, s_k, tL_k + R_k) dk + R. \tag{22}$$

The regulator maximizes household utility (17) by its policy parameters $\{m_i\} \doteq \{b_i | \, i \in [0,1]\}$ and $\{s_i\} \doteq \{b_i | \, i \in [0,1]\}$ subject to the tax function (21) and consumption (22), given the contributions R_i of the regions $i \in [0,1]$ as functions of the policy parameters. The remainder of this article considers two cases: regulation without and with subsidies.

[5]The assumption of the common representative household implies that the marginal utility of income is the same for the regulator and the countries. The alternative is the model of Dixit et al. (1997), in which the regulator's utility $W(u, R)$ is an increasing function of both the household's utility u and total political contributions R. With that extension, distributional considerations would complicate the analysis, without any qualitative impact on the results that concern the subsidies and regulatory stardards.

6 Regulation without subsidies

Assume that there are no subsidies, and consequently no tax, $s_i = t = 0$ for $i \in [0,1]$, so that the regulatory standards $\{m_i\} \doteq \{b_i | \, i \in [0,1]\}$ are the only policy instruments. The revenue of country i, (8), then becomes [cf. (2), (9), (11) and (12)]

$$\Pi_i(m_i, 0, R_i), \;\; \frac{\partial \Pi_i}{\partial m_i} = -f_n^i(L_i - z_i, N_i - b_i, z_i), \;\; \frac{\partial \Pi_i}{\partial R_i} = -1, \;\; b_i = m_i. \quad (23)$$

Furthermore, given $s_i = 0$, from the equilibrium condition (10) of a region it follows that

$$f_z^i(L_i - z_i, N_i - b_i, z_i) = f_l^i(L_i - z_i, N_i - b_i, z_i) \;\text{ for } i \in [0,1]. \quad (24)$$

Country i maximizes its revenue (23) by its contribution function $R_i(m_i)$ [cf. (iii) in Appendix B]:

$$m_i = \arg\max_{m_i} \Pi_i\big(m_i, 0, R_i(m_i)\big). \quad (25)$$

Given the contribution functions, total contributions (6) become

$$R = \int_0^1 R_i(m_i) di. \quad (26)$$

The regulator maximizes its utility (17) by its policy $\{m_i\}$ subject to the utilities of countries, (25), and total contributions (26) [cf. (ii) in Appendix B]. This condition can be written as follows:

$$\{m_i\} = \arg\max_{\{m_i\}} u(c, \{m_i\}) \quad \text{with} \quad c = \int_0^1 \Pi_i(m_i, 0, R_i) di + \int_0^1 R_i(m_i) di. \quad (27)$$

The equilibrium condition of country i, (25), is equivalent to the first-order condition

$$0 = \frac{\partial \Pi_i}{\partial b_i} + \frac{\partial \Pi_i}{\partial R_i}\frac{\partial R_i}{\partial m_i}.$$

Given (23), this can be written also as follows:

$$\frac{\partial R_i}{\partial m_i} = -\frac{\partial \Pi_i}{\partial m_i}\bigg/\frac{\partial \Pi_i}{\partial R_i} = \frac{\partial \Pi_i}{\partial m_i} = -f_n^i. \quad (28)$$

Conditions (28) say that in equilibrium the change in the contributions of country i, R_i, due to a change in any instrument m_i equals the effect of that instrument on the revenue of that country, Π_i. These contribution schedules are locally truthful. This concept can be extended to a globally truthful contribution schedule that represents the preferences of country i at all policy points (cf. Dixit et al. 1997) as follows:

$$R_i = \max[\Pi_i - \underline{\pi}_i, 0], \tag{29}$$

where the integration constant $\underline{\pi}_i$ is the opportunity revenue of country i in case it does not pay contributions, $R_i = 0$, but the regulator chooses its best response, given the contribution schedules of other countries $k \neq i$ [cf. (15)].

Given (28), the regulator's equilibrium conditions (27) are equivalent to the first-order conditions

$$0 = \frac{\partial u}{\partial m_i} + \frac{\partial u}{\partial c}\frac{\partial R_i}{\partial m_i} = \frac{\partial u}{\partial m_i} - f_n^i \frac{\partial u}{\partial c} \text{ for } i \in [0,1]. \tag{30}$$

The conditions (24) and (30) are equivalent to the Pareto optimality conditions (18) and (19). In other words:

Proposition 2 *Without subsidies, regulation leads to the Pareto optimum.*

7 Regulation with subsidies

Assume that each country i can credibly commit itself to its contribution function $R_i(m_i, s_i)$ with any strategy (m_i, s_i). Country i maximizes its revenue (8) by its contribution function $R_i(m_i, s_i)$, given the tax function (21):

$$(m_i, s_i) = \arg\max_{m_i, s_i} \Pi_i\Big(m_i, s_i, t\big(\{m_k\}, \{s_k\}\big) L_i + R_i(m_i, s_i)\Big). \tag{31}$$

These are equivalent to the first-order conditions

$$0 = \frac{\partial \Pi_i}{\partial m_i} + \frac{\partial \Pi_i}{\partial (t_i + R_i)}\frac{\partial R_i}{\partial m_i}, \quad 0 = \frac{\partial \Pi_i}{\partial s_i} + \frac{\partial \Pi_i}{\partial (t_i + R_i)}\frac{\partial R_i}{\partial s_i}.$$

Given (9) and (12), these equations can be written also as follows:

$$\begin{aligned} \frac{\partial R_i}{\partial m_i} &= -\frac{\partial \Pi_i}{\partial m_i}\Big/\frac{\partial \Pi_i}{\partial (t_i + R_i)} = \frac{\partial \Pi_i}{\partial m_i} = s_i\big(V_m^i + V_b^i\big) - f_n^i, \\ \frac{\partial R_i}{\partial s_i} &= -\frac{\partial \Pi_i}{\partial s_i}\Big/\frac{\partial \Pi_i}{\partial (t_i + R_i)} = \frac{\partial \Pi_i}{\partial s_i} = V^i. \end{aligned} \tag{32}$$

Conditions (32) say that in equilibrium the change in the contributions of country i, R_i, due to a change in any instrument (m_i or s_i) is equal to the effect of that instrument on the revenue of that country, Π_i. Thus, the contribution schedules are locally truthful. This concept can be extended to a globally truthful contribution schedule that represents the preferences of country i at all policy points. Given (32), the truthful contribution functions are $R_i = \max[\Pi_i - \underline{\pi}_i, 0]$, where the revenue $\underline{\pi}_i$ of country i with no contributions $R_i = 0$ is the same (15) as before.

Given the contribution functions, total contributions (6) become

$$R = \int_0^1 R_i(m_i, s_i)di. \tag{33}$$

The regulator maximizes its utility (17) by its policy $\{m_k, s_k\}$ subject to the contributions it receives, (33), the response functions (14) and the behavior (31) of the countries $i \in [0,1]$:

$$\begin{aligned} &\{m_i, s_i\} = \arg\max_{\{m_i,s_i\}} u(c, \{b_i(m_i, s_i)\}) \text{ with} \\ &c = \int_0^1 \Pi_\kappa\Big(m_\kappa^*,\, s_\kappa^*,\, t\big(\{m_k\}, \{s_k\}\big)L_\kappa + R_\kappa(m_\kappa^*, s_\kappa^*)\Big)d\kappa + \int_0^1 R_i(m_i, s_i)di, \end{aligned} \tag{34}$$

where the optimal values m_i^* and s_i^* of the maximization (31) must be taken as given. Defining the function $U(\{m_i, s_i\}) \doteq u(c, \{b_i(m_i, s_i)\})$ and noting (9), (32) and (34), one obtains that

$$\begin{aligned} \frac{\partial U}{\partial m_i} &= \frac{\partial u}{\partial c}\left\{\frac{\partial R_i}{\partial m_i} + \left[\int_0^1 \underbrace{\frac{\partial \Pi_\kappa}{\partial(t_\kappa + R_\kappa)}}_{=-1} L_\kappa d\kappa\right]\frac{\partial t}{\partial m_i}\right\} + \frac{\partial u}{\partial b_i}\frac{\partial b_i}{\partial m_i} \\ &= \frac{\partial u}{\partial c}\left[s_i\big(V_m^i + V_b^i\big) - f_n^i - \left(\int_0^1 L_\kappa d\kappa\right)\frac{\partial t}{\partial m_i}\right] + \frac{\partial u}{\partial b_i}\frac{\partial b_i}{\partial m_i} \text{ for } i \in [0,1], \end{aligned} \tag{35}$$

$$\begin{aligned} \frac{\partial U}{\partial s_i} &= \frac{\partial u}{\partial c}\left\{\frac{\partial R_i}{\partial s_i} + \left[\int_0^1 \underbrace{\frac{\partial \Pi_\kappa}{\partial(t_\kappa + R_\kappa)}}_{=-1} L_\kappa d\kappa\right]\frac{\partial t}{\partial s_i}\right\} + \frac{\partial u}{\partial b_i}\frac{\partial b_i}{\partial s_i} \\ &= \frac{\partial u}{\partial c}\left[V^i - \left(\int_0^1 L_\kappa d\kappa\right)\frac{\partial t}{\partial s_i}\right] + \frac{\partial u}{\partial b_i}\frac{\partial b_i}{\partial s_i} \text{ for } i \in [0,1]. \end{aligned} \tag{36}$$

Given (13), (21), (35) and (36), it holds true that

$$\left.\frac{\partial U}{\partial m_i}\right|_{s_k=0\,\forall k\in[0,1]} = \frac{\partial u}{\partial c}\left[-f_n^i - \left(\int_0^1 L_\kappa d\kappa\right)\underbrace{\left.\frac{\partial t}{\partial m_i}\right|_{s_k=0\,\forall k\in[0,1]}}_{=0}\right] + \frac{\partial u}{\partial b_i}\underbrace{\left.\frac{\partial b_i}{\partial m_i}\right|_{s_i=0}}_{=1} = -f_n^i\frac{\partial u}{\partial c} + \frac{\partial u}{\partial b_i} \text{ for } i \in [0,1], \tag{37}$$

$$\left.\frac{\partial U}{\partial s_i}\right|_{s_k=0\,\forall k\in[0,1]} = \frac{\partial u}{\partial c}\underbrace{\left[V^i - \left(\int_0^1 L_\kappa d\kappa\right)\frac{\partial t}{\partial s_i}\right]}_{=0} + \frac{\partial u}{\partial b_i}\frac{\partial b_i}{\partial s_i} = \underbrace{\frac{\partial u}{\partial b_i}}_{+}\underbrace{\frac{\partial b_i}{\partial s_i}}_{+} > 0. \tag{38}$$

Given (10) and (37), the Pareto optimality conditions (18) and (19) hold true with zero subsidies, $s_k = 0$ for $k \in [0,1]$:

$$\left.\frac{\partial U}{\partial m_i}\right|_{s_k=0\,\forall k\in[0,1]} = \frac{\partial u}{\partial b_i} - f_n^i = 0, \quad \left(f_z^i - f_l^i\right)_{s_i=0} = 0.$$

However, the inequality (38) shows that this cannot be the equilibrium: because the possibility to set subsidies improves the regulator's bargaining position, the regulator has incentives to increase the subsidies s_i of all countries $i \in [0,1]$ above zero. Noting (14), this promotes conservation, $\frac{\partial b_i}{\partial s_i} > 0$ in all countries $i \in [0,1]$. The results can be summarized as follows:

Proposition 3 *Conservation subsidies are welfare decreasing, leading to excessive conservation.*

The international budget for distributing subsidies increases the regulator's bargaining power and political contributions it receives from the countries. Consequently, the regulator introduces subsidies that distort the allocation of labor between the private and government sectors.

8 Conclusions

This article considers an economy where the conservation of environmental resources yields utility through conservation. Firms make goods from labor and natural resources, benefiting from public services. The countries produce public services from labor and lobby the regulator that runs conservation management. The policy instruments consists of regulatory standards and the subsidies to conserved resources over and above those standards, with the latter being financed by non-distorting taxes.

The main findings are the following. Lobbying for regulatory standards alone leads to Pareto efficiency. The international budget for distributing subsidies increases the regulator's bargaining power and political contributions it receives from the countries. Consequently, the regulator introduces subsidies, although these distort the allocation of labor between the private and government sectors. These results, however, depend on two realistic assumptions: first, there are public inputs to production in the countries; and second, the regulator has interests of its own. If there were no public services, then all labor would be employed in production and the subsidies could not distort the the allocation of labor. On the other hand, a fully benevolent regulator would not introduce conservation subsidies alongside regulatory standards.

Furthermore, the analysis is based on two simplifying assumptions. The first of these is that there are only non-distorting taxes. Given the result of Palokangas (2013), a distorting revenue-raising tax would lead to Pareto inefficiency, which strengthens the result of this article. The second assumption is that the regulator belongs to the representative household. This clarifies the results, for changes of income distribution due to political contributions do not affect efficiency in the model. Alternatively, one could use the model of Dixit et al. (2007), in which the regulator's utility is an increasing function of both the household's utility and the political contributions. This extension would complicate the analysis, without nullifying the results of this article concerning the subsidies and regulatory stardards.

While a great deal of caution should be exercised when a highly stylized game-theoretical model is used to derive results on conservation management, the following conclusion seems nevertheless to be justified. Applied to NATURA 2000, the power to set regulatory standards is appropriate in the EU. If there is any reason to believe that the policy makers in the EU have interests of their own, the use of "co-financing" alongside regulatory standards in conservation management can decrease welfare.

Appendix

A Results (8), (9), (10), (11), (12) and (14)

Country i maximizes maximizes

$$\pi_i(z_i, b_i, m_i, s_i, t_i + R_i) \doteq f^i(\underbrace{L_i - z_i}_{l_i}, \underbrace{N_i - b_i}_{n_i}, z_i) + s_i V^i(z_i, b_i, m_i) - t_i - R_i \tag{39}$$

by (z_i, b_i) subject to $b_i \geq m_i$. The Lagrangean for this maximization is

$$\Lambda \doteq \pi_i + \lambda(b_i - m_i), \tag{40}$$

where the multiplier λ satisfies the Kuhn-Tucker conditions

$$\lambda \geq 0, \quad \lambda(b_i - m_i) = 0. \tag{41}$$

Noting (39) and (40), one obtains the first-order conditions

$$\frac{\partial \Lambda}{\partial z_i} = \frac{\partial \pi_i}{\partial z_i} = s_i V_z^i(z_i, b_i, m_i) - f_l^i(L_i - z_i, N_i - b_i, z_i) + f_z^i(L_i - z_i, N_i - b_i, z_i)$$
$$= 0, \tag{42}$$
$$\frac{\partial \Lambda}{\partial b_i} = \frac{\partial \pi_i}{\partial b_i} + \lambda = s_i V_b^i(z_i, b_i, m_i) - f_n^i(L_i - z_i, N_i - b_i, z_i) + \lambda = 0. \tag{43}$$

Condition (42) is equivalent to (10). Noting (39), (40), (41) and (43), one can define the function (8),

$$\Pi_i(m_i, s_i, t_i + R_t) \doteq \max_{z_i, b_i \geq 0} \pi_i = \max_{z_i, b_i} \Lambda,$$

with the properties

$$\frac{\partial \Pi_i}{\partial s_i} = \frac{\partial \Lambda}{\partial s_i} = \frac{\partial \pi_i}{\partial s_i} = V^i, \quad \frac{\partial \Pi_i}{\partial (t_i + R_i)} = \frac{\partial \Lambda}{\partial (t_i + R_i)} = \frac{\partial \pi_i}{\partial (t_i + R_i)} = -1,$$
$$\frac{\partial \pi_i}{\partial b_i} = s_i V_b^i(z_i, b_i, m_i) - f_n^i(L_i - z_i, N_i - b_i, z_i) = -\lambda \begin{cases} = 0 & \text{for } b_i > m_i, \\ < 0 & \text{for } b_i = m_i, \end{cases}$$
$$\frac{\partial \Pi_i}{\partial m_i} = \frac{\partial \Lambda}{\partial m_i} = \frac{\partial \pi_i}{\partial m_i} - \lambda = s_i V_m^i - \lambda$$
$$= s_i \big[V_m^i(z_i, b_i, m_i) + V_b^i(z_i, b_i, m_i)\big] - f_n^i(L_i - z_i, N_i - b_i, z_i),$$

which are equivalent to (9), (11) and (12).

Finally, consider the case $b_i > m_i$. Then, $\lambda = 0$ holds by (41) and the second-order conditions are

$$\frac{\partial^2 \pi_i}{\partial z_i^2} < 0, \quad \mathcal{J} \doteq \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} > 0. \tag{44}$$

Furthermore, from (5), (42) and (43) it follows that

$$\left.\frac{\partial^2 \pi_i}{\partial b_i \partial z_i}\right|_{s_i=0} = f^i_{ln} - f^i_{nz}, \quad \left.\frac{\partial^2 \pi_i}{\partial z_i^2}\right|_{s_i=0} = f^i_{ll} - 2f^i_{lz} + f^i_{zz}, \quad \left.\frac{\partial^2 \pi_i}{\partial b_i^2}\right|_{s_i=0} = f^i_{nn},$$
$$\frac{\partial^2 \pi_i}{\partial b_i \partial s_i} = V^i_b = f^i_n - b_i f^i_{nn}, \quad \frac{\partial^2 \pi_i}{\partial z_i \partial s_i} = V^i_z = b_i(f^i_{nz} - f^i_{ln}) = -b_i \left.\frac{\partial^2 \pi_i}{\partial b_i \partial z_i}\right|_{s_i=0}. \tag{45}$$

Given (2), (44) and (45), one obtains

$$\begin{aligned}
\left.\frac{\partial b_i}{\partial s_i}\right|_{s_i=0} &= -\frac{1}{\mathcal{J}} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i \partial s_i} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ \frac{\partial^2 \pi_i}{\partial z_i \partial s_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} = -\frac{1}{\mathcal{J}} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i \partial s_i} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ -b_i \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} \\
&= -\frac{1}{\mathcal{J}} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i \partial s_i} + b_i \frac{\partial^2 \pi_i}{\partial b_i^2} - b_i \frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ -b_i \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} \\
&= -\frac{1}{\mathcal{J}} \begin{vmatrix} -b_i \frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ -b_i \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} - \frac{1}{\mathcal{J}} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i \partial s_i} + b_i \frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ 0 & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} \\
&= \frac{b_i}{\mathcal{J}} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} - \frac{1}{\mathcal{J}} \begin{vmatrix} f^i_n - b_i f^i_{nn} + b_i f^i_{nn} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ 0 & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} \\
&= \underbrace{b_i}_{+} - \underbrace{\frac{1}{\mathcal{J}}}_{+} \underbrace{f^i_n}_{+} \underbrace{\frac{\partial^2 \pi_i}{\partial z_i^2}}_{-} > 0.
\end{aligned}$$

B The lobbying game

Following Dixit et al. (1997), a subgame perfect Nash equilibrium for this game is a policy ζ and a set of contribution schedules $R_1(\zeta), ..., R_i(\zeta)$ such that the following conditions $(i) - (iv)$ hold:

(i) Contributions R_i are non-negative but no more than the contributor's income, $U^i \geq 0$.

(ii) The policy ζ maximizes the regulator's welfare taking the contribution schedules R_i as given.

(iii) Country i cannot have a viable strategy $R_i(\zeta)$ that yields it a higher level of utility than in equilibrium, given the others' contributions.

(iv) Country i provides the regulator at least with the level of utility as in the case in which it offers nothing ($R_i = 0$), and the regulator responds optimally given the contribution functions of the other countries.

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